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US ARMY MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

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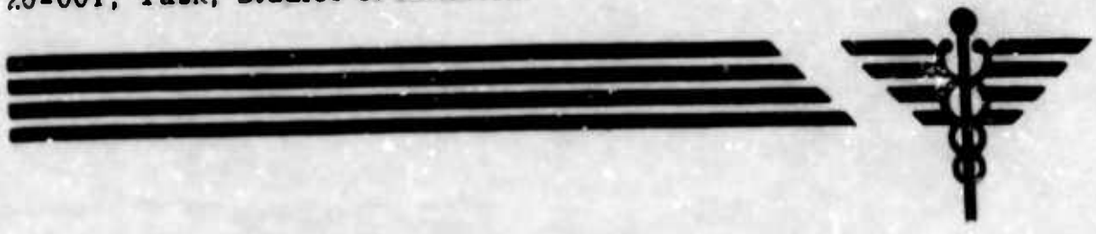
COMPARISON OF ATTENUATION CHARACTERISTICS OF THE ACOUSTIC REFLEX AND THE V-51R EARPLUG*

*Task under Psychophysiological Studies, USAMRL Project No. 6-95-20-001, Task, Studies of Audition.



UNITED STATES ARMY
MEDICAL RESEARCH AND DEVELOPMENT COMMAND

REPORT NO. 397

COMPARISON OF ATTENUATION CHARACTERISTICS OF THE ACOUSTIC REFLEX AND THE V-51R EARPLUG*

by

John L. Fletcher

from

Psychology Division
US ARMY MEDICAL RESEARCH LABORATORY
FORT KNOX, KENTUCKY

*Task under Psychophysiological Studies, USAMRL Project No. 6-95-20-001, Task, Studies of Audition.

Report No. 397
Project No. 6-95-20-001
Task USAMRL T-1
MEDEA

ABSTRACT

COMPARISON OF ATTENUATION CHARACTERISTICS OF THE ACOUSTIC REFLEX AND THE V-51R EARPLUG

OBJECT

To compare the attenuation characteristics of the acoustic reflex and the V-51R earplug.

RESULTS

Pre- and post-exposure thresholds were obtained for 13 subjects exposed under two conditions to 100 rounds of machine gun fire (fired one round at a time). In condition I the acoustic reflex (AR) was activated to protect the listener and in condition II protection was afforded by the V-51R earplug. Results show protection by the AR superior to that of the V-51R up to 1000 cps, markedly inferior at and above 2000 cps.

RECOMMENDATIONS

It is recommended that:

1. The AR be utilized as an ear protective mechanism where low frequency noise of an impulse type predominates.

2. Further research should be done to study possible extensions of the usefulness of the AR as a protective mechanism. Specifically, steps should be taken to develop and test an AR ear protective device. Crew members in armored vehicles undergo considerable exposure to firing during training. Organic to armored vehicles is a radio intercom system. Suitability of this system as part of an AR protective device should be investigated.

Submitted 7 July 1959 by:
John L. Fletcher, Captain, MSC

APPROVED: Ernest K. Montague
ERNEST K. MONTAGUE
Lt Colonel, MSC
Director, Psychology Division

APPROVED: Floyd A. Odell
FLOYD A. ODELL
Technical Director of Research

APPROVED: Harold W. Glascock Jr
HAROLD W. GLASCOCK, JR.
Colonel, Medical Corps
Commanding

COMPARISON OF ATTENUATION CHARACTERISTICS OF THE ACOUSTIC REFLEX AND THE V-51R EARPLUG

I. INTRODUCTION

The preceding study in this series (1) demonstrated that a 98 db (re. .0002 dyne cm^2) 1000 cps tone sounded just prior to exposure to repeated impulse sounds resulted in significantly smaller temporary threshold shifts (TTS) than when the tone was not sounded. The tone was of a frequency and intensity calculated to activate the intra-aural muscles (tensor tympani and stapedius). These muscles when contracted as a result of acoustic, mechanical, or electrical stimulation, constitute the acoustic reflex, or AR, and have been shown to damp high level sound transmission through the ears.

The results of the above study did not permit comparison of the protective characteristics of the reflex action with that of commercially available protection. The lack of data regarding the relative amount of protection afforded man by the reflex action suggests that it would be worthwhile to determine, under identical conditions, the TTS of subjects protected by reflex action as compared with their TTS when protected by a good commercially available protector (the V-51R earplug).

Results from the literature indicate that the AR attenuates relatively more in the low than in the high frequency region. Wiggers (2) in an electrophysiological study on animals reports about 45 db attenuation at 100 cps and says that "during contractions of the tensor tympani and the stapedius transmission loss increases linearly with a decrease in frequency." In another investigation Wiggers (3) found that most of the attenuation effect is on tones of 1000 cps or less. Data from the preceding study, however, showed very good protection (in db TTS) at frequencies above 1000 cps. The term protection is used in connection with this study because TTS data were obtained, therefore no appropriate measure of attenuation was available.

If the acoustic reflex is indeed more efficient at low than at high frequencies it might possibly be the solution to providing adequate protection against sounds with high energy levels in the low frequency region. Many problems, including those of fit and seal, prevent existing ear protective

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[1]The writer wishes to acknowledge the contribution of Captain David Hilding, Ireland Army Hospital, Fort Knox, Kentucky, who performed the otological examination of the subjects used in this study.

devices from providing really good attenuation of low frequency sound. Certainly, 45 db at 100 cps would be almost twice the attenuation of the best commercial device or combination of devices.

The V-51R earplug was selected as the protector for comparison with the acoustic reflex because it is widely used and there are considerable data attesting to its effectiveness and describing its characteristics. Neff (Benox Rep. pg. 44) says "There is no evidence that any other kind of ear defender offers better protection from noise than the V-51R; many kinds are definitely inferior." As presented in the Benox report, the V-51R, black neoprene plug provides about 28 db attenuation at 100 cps, 30 db at 500 cps, 30 db at 1000 cps, 42 db at 2000 cps, 38 db at 3000 cps, 33 db at 4000, 40 db at 6000 cps and 42 db at 8000 cps.

II. METHOD

The method followed in this study was identical with that used in the previous study. Complete otological examinations were obtained on all subjects used in this experiment prior to data collection. Wax was removed where indicated, and several prospective subjects with fluid in their ears were disqualified from participation. All subjects participating had negative otological findings (ear, nose, and throat). Thirteen subjects, trained in using the Bekesy audiometer (Grason-Stadler Type E800) to determine their thresholds, were brought in and their threshold obtained immediately before firing. As soon as firing ceased their threshold was again determined. Tracings were begun within 8-30 sec after the last round was fired. The thresholds were for sweep frequencies from 250-8000 cps. Each subject fired one course with no protection, one with the acoustic reflex contracted, and one with V-51R earplugs. Pre- and post-exposure audiograms obtained under the three conditions were compared to determine TTS following exposure. The TTS's from the two experimental conditions were then analyzed by a 2 x 8 x 13 analysis of variance to determine the significance of the differences obtained.

III RESULTS

Examination of the results of this study shows that there was a significant difference in the attenuation provided by the reflex and the plug. Figure 1, page 6, plots the TTS's for all three conditions resulting from exposure to the firing noise. Over-all mean TTS was 19.23 db with no protection, 6.27 db with the acoustic reflex, and 2.50 db with the V-51R. Subjects in this experiment, as in the preceding one, differed significantly among themselves with regard to TTS. Our raw data showed that 5 out

of 13 subjects had little or no TTS after exposure to the firing noise. The remaining 8 persons had large TTS. Of those with post-exposure threshold shifts, some appeared to be almost completely protected by both the acoustic reflex and the plug, while others were better protected by the acoustic reflex. Figures 2a and 2b, pages 7 and 8, contain some of the raw data obtained in this study and give an idea of the individual differences in reaction mentioned above.

Data in Figure 1 show that the acoustic reflex provides more protection up to and including 1000 cps than does the V-51R. Protection at and above 2000 cps was greater for the V-51R. The analysis of variance test showed a significant frequency X conditions interaction that can best be explained by the selective attenuation results discussed above. Complete results of the analysis of variance are shown by Table 1.

TABLE 1

SUMMARY OF ANALYSIS OF VARIANCE

Source	SS	DF	Mean Square	F	Error Term
1. Subjects (S)	3152	12	263	3.13**	7
2. Frequencies (F)	620	7	89	1.56	4
3. Conditions (C)	739	1	739	6.78*	5
4. S x F	4783	84	57	...	7
5. S x C	1301	12	109	1.43	7
6. F x C	2001	7	286	3.76**	7
7. S x F x C	6406	84	76		

* Significant at the 5% level of confidence.

** Significant at the 1% level of confidence.

IV. DISCUSSION

Results obtained in this study in general support the findings of Wiggers (2 and 3). Attenuation characteristics of the V-51R (30 db or more) lead one to expect good protection for frequencies above 1000 cps. The superior performance of the reflex in the 1000 cps region suggests that it provides in excess of 30 db attenuation in this region. We arrive at this figure by reasoning thus: the V-51R attenuates about 30 db around 1000 cps and TTS is greater with the V-51R than with the reflex, therefore the reflex probably provides more attenuation than the plug.

Our results indicate that usefulness of the reflex is restricted, probably to situations where energy is high in the low frequency region.

Certainly the V-51R is cheaper and more efficient for sounds 2000 cps and above, provided the situation demanding ear protection is one where insert devices are appropriate.

V. SUMMARY

Pre- and post-exposure thresholds were obtained under two conditions for 13 subjects after firing 100 rounds, one round at a time, from a .30 cal. machine gun. In condition I, a 1000 cps tone at about 98 db (re. .0002 dyne cm^2) activated the acoustic reflex prior to each round, thus reducing TTS. Under condition II each subject was fitted with V-51R earplugs which were then inserted by the experimenter prior to exposure. Results show protection by the AR superior to that of the V-51R up to 1000 cps, markedly inferior at and above 2000 cps. Over-all average TTS after firing was greater for the AR than for the V-51R. The AR method of protection would seem to be profitable only where low frequency noise and attendant problems of fit, seal, and demands upon the wearer result in poor attenuation by artificial mean or in decreased communication ability.

VI. RECOMMENDATIONS

It is recommended that:

1. The AR be utilized as an ear protective mechanism where low frequency noise of an impulse type predominates.

2. Further research should be done to study possible extensions of the usefulness of the AR as a protective mechanism. Specifically, steps should be taken to develop and test an AR ear protective device. Crew members in armored vehicles undergo considerable exposure to firing during training. Organic to armored vehicles is a radio intercom system. Suitability of this system as part of an AR protective device should be investigated.

VII. REFERENCES

1. Fletcher, J. L. and A. J. Riopelle. The protective effect of the acoustic reflex for impulsive noises. USAMRL Report No. 396, Fort Knox, Ky., 1959.

2. Wiggers, H. C. The functions of the intra-aural muscles. Am. J. Physiol. 120: 771-780, 1957.

3. Wiggers, H. C. The effect of contraction of the intra-aural muscles on transmission of sound in the middle ear. Am J. Physiol. 119: 420, 1937.

4. Neff, W. D. Hearing losses and protective measures. Chapter IV, Benox Report. An exploratory study of the biological effects of noise. Contract N6 ori-020, Task Order 44, ONR Project NR -44079. The University of Chicago, 1953.

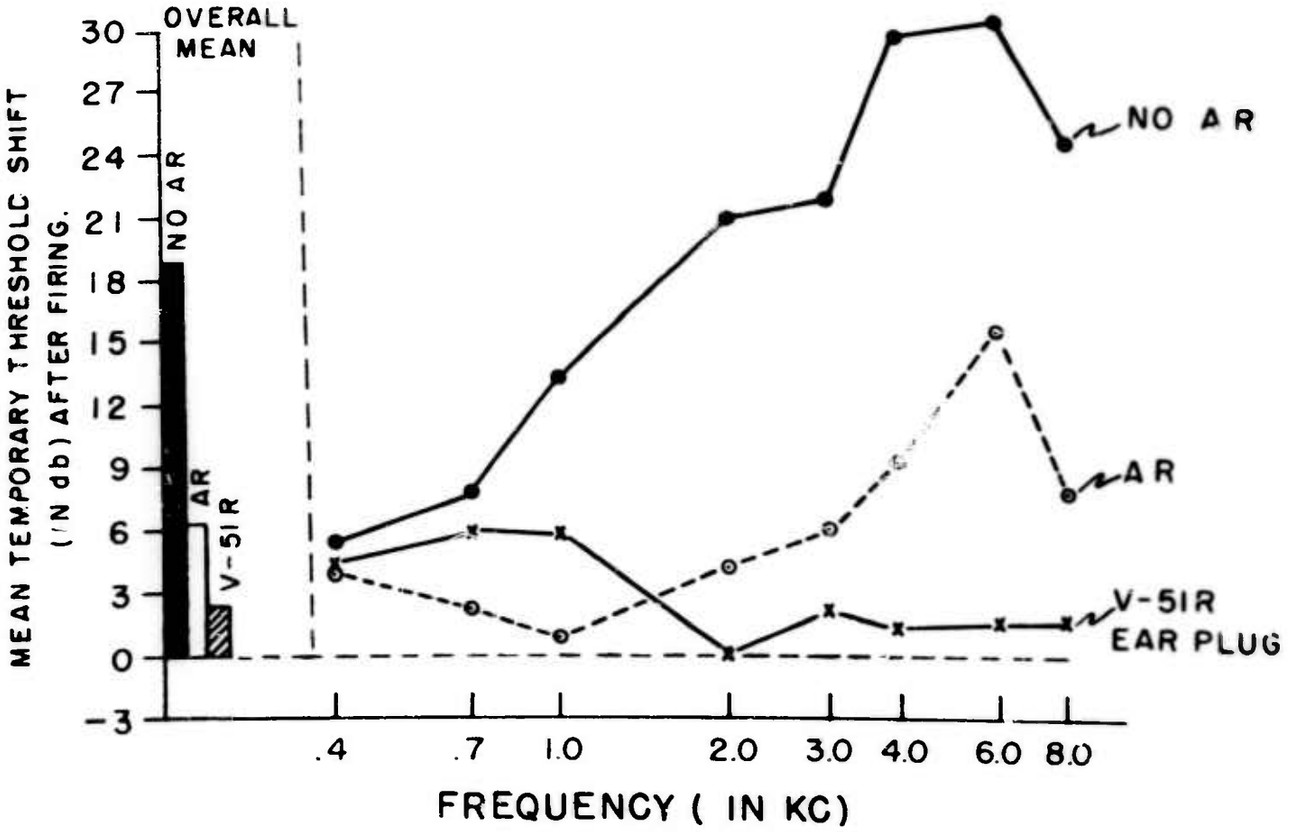

Fig. 1. Mean temporary threshold shift induced by three experimental conditions.

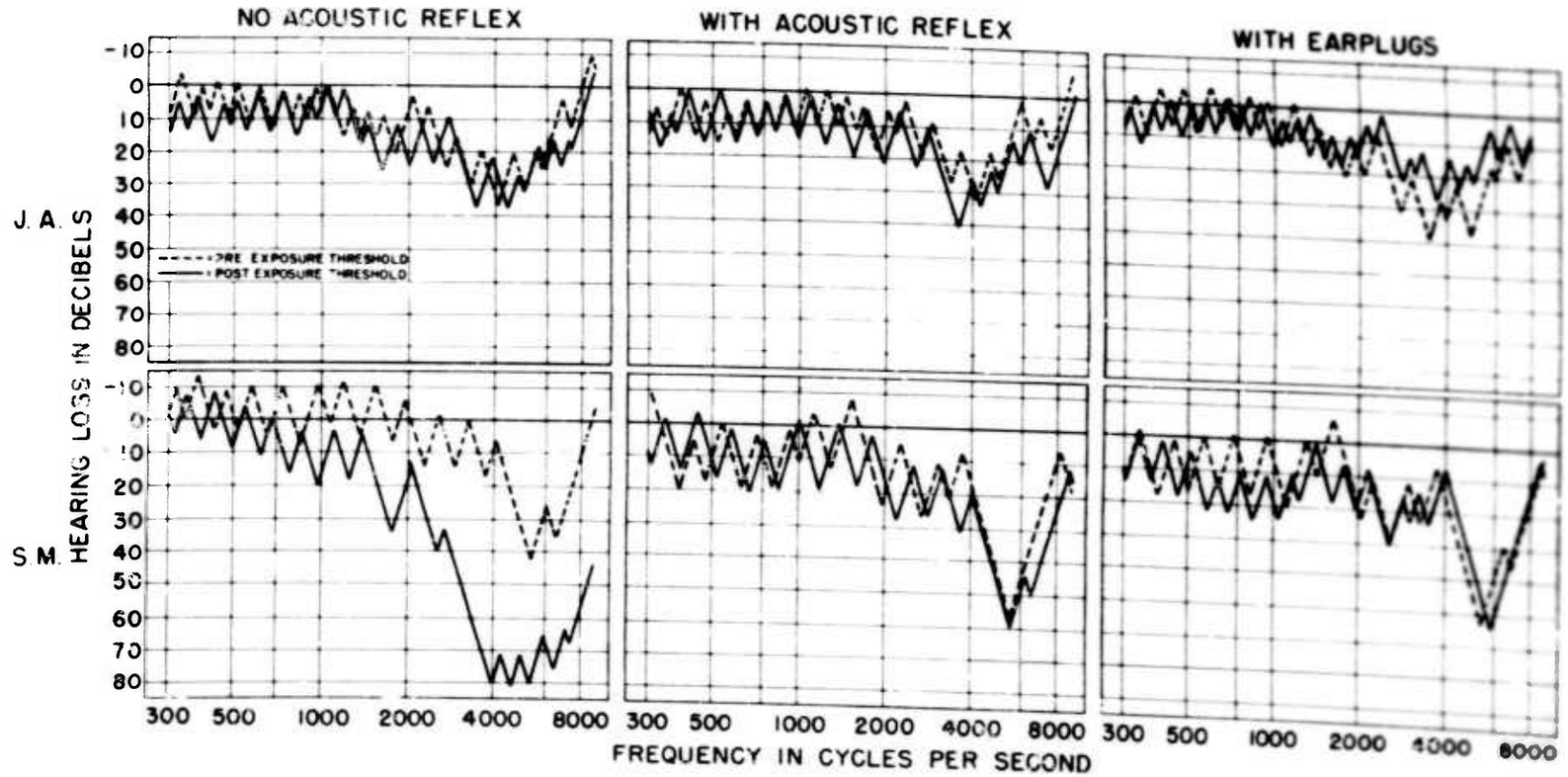

Fig. 2a. Representative audiograms for four subjects under three experimental conditions.

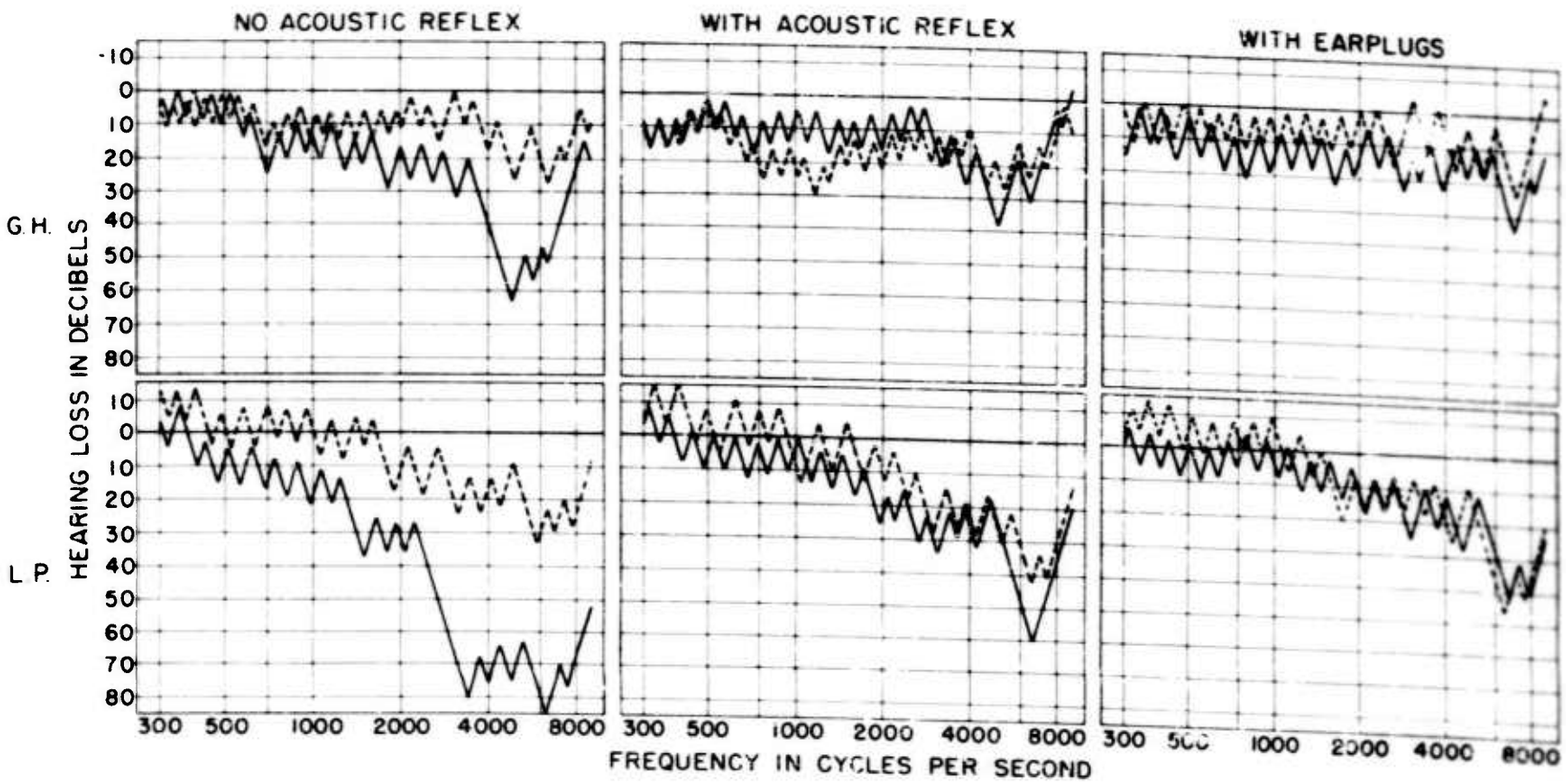

Fig. 2b. Representative audiograms for four subjects under three experimental conditions.